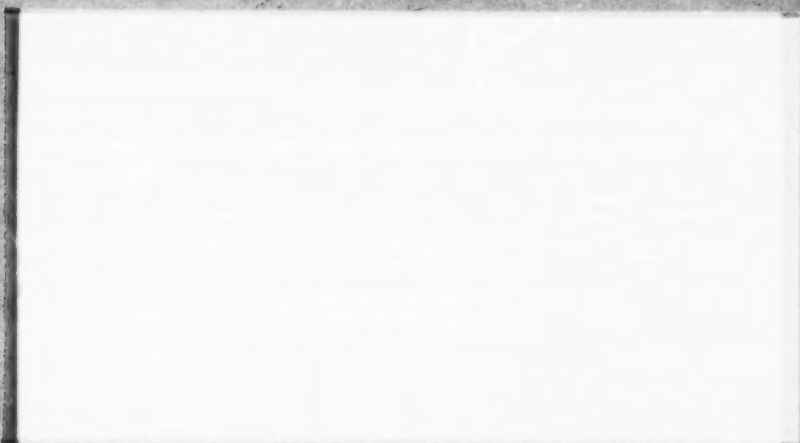




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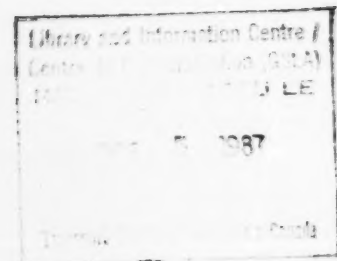
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TESTING AND PASSENGER DEMONSTRATION
OF THE BREL 141 LIGHT RAIL DIESEL CAR

Report by

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Prepared for

Transportation Development Centre
Montreal, Canada

December 1986

The contents of this report reflect the views of the author and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

Un sommaire en français de ce rapport est inclus avant la Table des matieres.

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17 Abstract

A test program is described of a British Rail Engineering Limited model 141 Light Diesel Rail Car to evaluate its suitability for service under Canadian conditions. The test program comprised signal activation tests, engineering and operational tests under winter conditions, and a non-revenue passenger service demonstration. The vehicle operated reliably, proving itself stable, comfortable and safe in the encountered conditions. Signal tests showed the vehicle to be capable of activating all types of track circuit signals up to the maximum speed tested of 97 km/h.

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17 Résumé

Ce rapport concerne le programme d'essais du railbus diesel modèle 141 fabriqué par la British Rail Engineering Limited et qui visait à éprouver ce véhicule dans les conditions climatiques propres au Canada. Ce programme a comporté des essais de déclenchement des signaux automatiques, des essais techniques et de marche en exploitation hivernale et une mise en service régulier pour le transport de passagers non payants. Le railbus s'est révélé fiable, stable, confortable et sûr dans toutes les conditions d'essais, en plus de se montrer apte à déclencher tous les signaux commandés par circuits de voie, jusqu'à la vitesse de marche maximale essayée de 97 km/h.

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SUMMARY

In February 1986, a British Rail Engineering Limited (BREL) Model 141 Light Rail Diesel Car (LRDC) was delivered to Montreal for technical tests and passenger demonstration runs to determine its suitability for service under Canadian conditions. In Montreal, as a condition to operation on CN lines, the LRDC underwent further modifications with the application of headlight, bell, horns and other necessary operational equipment.

This project was initiated by the Transportation Development Centre (TDC) of Transport Canada, which contracted with VIA Rail Canada to operate the vehicle and administer a pre-agreed test program. All tests were conducted on CN tracks. The test sites included CN sub-divisions to the west of Montreal (signals tests); the Lac St-Jean region (stability and winter operations in Quebec); and the Thompson-Pikwitonei-Thicket Portage circuit in northern Manitoba.

Because of late delivery of the vehicle, full winter testing could not be achieved; operations in this regard were limited to several snowy days in the Lac St-Jean region. They proceeded well, despite an alternator failure.

Essential engineering and operational tests were performed, with very encouraging results. These tests included instrumented measurements of the vehicle's stability, ride quality, and ability to activate signals at varying speeds. These evaluations were performed by the National Research Council under contract to TDC, and by CN.

In April, the vehicle was moved to Thompson for non-revenue scheduled passenger operation to the local communities of Pikwitonei and Thicket Portage. During the July-August period, it regularly operated in tri-weekly service to these communities, which are dependent upon the train for access to Thompson and other points.

The service gained a positive response, despite a passenger access problem; this resulted from the unit being configured for high-level platform entry.

Throughout the project, the LRDC operated reliably, proving itself stable, comfortable and safe in the encountered conditions. In the series of automatic signal tests, the vehicle activated all types of track circuit signals at speeds up to the maximum of 96.6 km/h (60 mph). Crews liked the unit and found it easy to operate.

Because of the limited total mileage operated, projections as to its economy, reliability, and maintenance requirements under Canadian conditions will require further verification. Indications to date are that the LRDC may have the potential to provide economic and acceptable levels of service. During the test period, maintenance demands were very light. The unit was based in the open and maintenance was performed without the use of pits or shops during its Thompson service. For this service, fuel economy was estimated at 26 1/100 km - 28 1/100 km, (11-12 miles per gallon) with varying passenger loads over flat terrain.

Questions remain as to the ability of the drive train to handle varying conditions such as sustained "slow order" operations and to meet acceptable acceleration, grade climbing, and upper speed requirements.

CONCLUSIONS

Throughout the tests all automatic signals were activated without exception.

The vehicle showed no tendency to become unstable at any speed achieved.

Operation of the vehicle is safe up to the tested speeds with maximum range of 96.6 km/h (60 mph).

Comfort is adequate for short and medium length journeys.

SOMMAIRE

En février 1986, un railbus diesel modèle 141 fabriqué par la British Rail Engineering Limited (BREL) est arrivé à Montréal en vue de subir des essais techniques et d'exploitation en service expérimental dans les conditions climatiques propres au Canada. A Montréal, aux termes de l'accord concernant l'exploitation du railbus sur le réseau du CN, ce véhicule a reçu des équipements supplémentaires, y compris des projecteurs, une cloche et des avertisseurs.

Lancé par le Centre de développement des transports (CDT) de Transports Canada, ce projet a été confié à VIA Rail; il s'agissait de faire subir au véhicule, sur les voies du CN, un programme d'essais convenu d'avance et établi comme suit: ouest de Montréal, essais de déclenchement des signaux; région du lac St-Jean, stabilité de marche et exploitation hivernale; Manitoba du nord, service expérimental sur le circuit Thompson-Pikwitonei-Thicket Portage.

Etant donné l'arrivée tardive du railbus, le programme hivernal n'a pu être exécuté au complet. Cependant, les essais réalisés durant les quelques jours où il a neigé au lac St-Jean ont donné de bons résultats, malgré une panne de l'alternateur.

Les principaux essais techniques et de marche qui ont été faits ont eu des résultats très encourageants: stabilité de marche, confort de roulement et aptitude à déclencher les signaux à des vitesses de marche variables. Ces essais ont été faits par le Conseil national de recherches, aux termes d'un contrat avec le CDT, et par le CN.

En avril, le railbus a été mis en service régulier non payant entre Thompson et Pikwitonei, d'une part, et Thicket Portage, d'autre part. En juillet et en août, il a assuré trois fois par semaine la liaison entre Thompson et ces deux localités, lesquelles ne sont desservies par aucun autre moyen de transport.

Ce service a été bien accueilli malgré un problème d'accès au railbus, dû à la hauteur de sa plate-forme qui est supérieure à celle des quais.

Tout au long, le railbus s'est montré fiable, stable, confortable et sûr et, dans la série d'essais de signalisation, il a déclenché automatiquement tous les signaux commandés par circuits de voie, jusqu'à la vitesse de marche maximale de 96.6 km/h (60 mi/h). Quant au personnel, il a trouvé le railbus agréable et facile à conduire.

Le kilométrage total parcouru ayant été relativement faible, il faudra procéder à d'autres vérifications visant à valider les prévisions sur la fiabilité des coûts d'exploitation et d'entretien, dans les conditions climatiques propres au Canada. Néanmoins, tout indique que le railbus est apte à fournir des services de qualité acceptable à un coût également acceptable. Durant les essais, peu d'entretien a été nécessaire. Le travail se faisait à l'extérieur et n'a jamais nécessité d'installations particulières (fosses d'entretien ou ateliers spécialisés). La consommation s'est établie entre 26 et 28 litres les 100 km, soit de 11 à 12 milles au gallon, dans des conditions de charge variables sur terrain plat.

Au sujet de la résistance du groupe propulseur à diverses conditions de service particulières, certains aspects restent encore à approfondir, comme la marche continue à vitesse réduite et sa tenue aux exigences d'accélération, de traction en rampe et de vitesse maximale.

CONCLUSIONS

Bonne fiabilité dans des conditions hivernales modérées.

Déclenchement de tous les signaux, sans exception.

Aucune tendance à l'instabilité, quelle que soit la vitesse.

Sécurité de marche à toutes les vitesses essayées, jusqu'à la vitesse maximale de 96.6 km/h (60 mi/h).

Bon confort sur les parcours de courte à moyenne durée.

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Annex*

1. British Rail Engineering Ltd. Railbus Demonstrator for Canada. 18 October 1985. Revised 29 November 1985.
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7. BREL LRDC Log Book

*The Annexes are published in a separate document, available upon request.
Title: "Technical Annexes to Report TP8166E, BREL 141 LRDC".

INTRODUCTION

This project was undertaken to evaluate a modern railbus technology for its applicability to Canadian conditions and requirements. Key concerns related to operational safety, operability, reliability, and the acceptance of this unit by the travelling public. Of particular interest was the potential of such equipment to serve lightly populated regions with rugged topography and harsh climates.

The attraction of the BREL 141 Railbus, hereafter referred to by the generic term Light Rail Diesel Car (LRDC), derived from both its design and its in-service experience elsewhere.

The British Rail Engineering - Leyland Model 141 LRDC, the object of the proposed tests, was the product of a railbus development program that had started in the 1970s. The BREL 141 had been extensively tested, and had been volume-ordered for service in the United Kingdom, along with its subsequent derivatives, the models 142, 143 and 144. As well as its acceptance for operation by British Rail, it had been tested and demonstrated in other nations, including Sweden, Norway, the United States, and in south east Asia.

The 141 has carried passengers in both non-revenue and revenue (regular) service, and has operated in both tropical and extreme cold conditions, as in Sweden (-38 C). While on demonstration to regional U.S.A. transportation authorities, the 141 gained operational experience under North American railroad conditions, including signalled territories and heavy-mixed traffic, with operators such as the ICG and Norfolk and Southern.

During the autumn and winter of 1985-1986, arrangements were made between Transport Canada (Transportation Development Centre), VIA Rail, CN, and British Rail Engineering to test a model 141 in Canada. The vehicle underwent certain modifications to meet Canadian requirements. Overall program management resided with TDC. The operating authority was vested in VIA Rail, which contracted to CN and through CN's consulting arm, CANAC, for LRDC test movements.

Approval to operate the unit was required from the Canadian Transport Commission to which briefings and applications were directed. A series of modifications were required in order to have the LRDC comply with Canadian regulations. At certain stages of the program specific operational restrictions were imposed to increase the safety margin until the equipment's capabilities were proven.

TECHNICAL TESTS: DESIGN AND IMPLEMENTATION

The Transportation Development Centre (TDC) apprised VIA in October 1985 of the imminent delivery of a British Rail Engineering Limited (BREL) model 141 railbus for evaluation as a remote area passenger vehicle in Canadian service. VIA was very interested to have the opportunity to compare this vehicle with other existing and proposed equipment.

The vehicle delivered was the same one that had undergone the tests in Sweden (1) and Norway (2) and had modifications to insulation, windows, heaters, power supply and battery chargers with cold weather in mind. Prior to shipping to Canada the vehicle was further modified in the BREL plant at Derby by installing a toilet with holding tank and heavier snow plows.

Preliminary test plans were drafted by VIA and TDC in conjunction with CN, CANAC, and the National Research Council (NRC) which provided a team to measure the required quantitative characteristics on road tests.

A SPEC (Structured Planning, Evaluation and Control) planning session was held with representatives from all the concerned organizations at the CPCS Management Systems Division headquarters on the 13 and 14 November 1985.

Discussions were held with representatives of the Canadian Transport Commission (CTC) and CN to decide what modifications and safety equipment would be required to satisfy the requirements of both organizations.

The vehicle was delivered in early February 1986 and was shipped to the workshops of Porte 7 Inc. at Ville St. Pierre (Montreal) to have modifications carried out.

Tests were made in the yard at Ville St. Pierre to satisfy CTC and CN representatives that the vehicle was safe to operate and was capable of being towed in the event of a breakdown.

On February 27, the vehicle journeyed to Jonquière in the Lac St. Jean region for road tests which included stability, curving, acceleration, braking, lighting and noise tests as well as a temperature survey.

Returning to Montreal for a stability test at 96.6 km/h (60 mph), which had not been attainable at Jonquière, the vehicle was then tested by CN personnel to verify its ability to operate DC, AFO, DC coded and motion detection automatic signal systems.

The vehicle was returned to Porte 7 Inc. for further modifications, including installation of emergency exit windows and was subsequently shipped by flat car to Thompson, Manitoba.

THE TEST VEHICLE

The test vehicle was a modified BREL model 141 railbus. Its general characteristics are described in Annex 1 "Railbus Demonstrator for Canada" issued by BREL. Some principal dimensions are:

Unit length over body	15,300 mm	(50 ft. 2 1/2 in.)
Unit length over snow plows	17,000 mm	(55 ft. 9 1/4 in.)
Body width excluding steps	2,500 mm	(8 ft. 2 1/2 in.)
Body width over steps	3,040 mm	(9 ft. 11 3/4 in.)
Wheelbase	9,000 mm	(29 ft. 6 1/4 in.)
Wheel diameter	800 mm	(31 1/2 in.)
Height of roof above rail	3.9 m	(12 ft. 9 3/4 in.)
Floor height above rail	1.2 m	(4 ft. 2 5/8 in.)
Coupler height above rail	806 mm	(2 ft. 7 3/4 in.)
Minimum curve negotiable	70 m radius	(230 ft.)
Estimated tare weight	28 tonnes	(61,740 lbs.)
Estimated gross laden weight	36 tonnes	(79,380 lbs.)

Previous Modifications to the Standard Model 141: for Tests in Sweden

The following list is taken from reference (1):

1. At each end a low frequency horn was provided above the windows.
2. At each end headlights were provided above the windows.
3. Electrical heated windows were provided.
4. The driver's valve was turned 180 degrees in order to obtain control directions identical to those on Swedish vehicles.

5. The doorways were provided with double windows and new sealings.
6. The side window of the vehicle was provided with double windows.
7. The car body was provided with additional insulation.
8. Partition walls were installed at the car ends.
9. Sand boxes with sanding equipment were introduced.
10. Rectifier for stationary charging of batteries were introduced.
11. Aerials with cable were provided.
12. Six heaters were provided at floor level.
13. The number of seats was reduced.
14. Chemical toilet were introduced.
15. Electrical heated outside rear view mirrors were provided at driver's side.
16. Outside rear view mirrors were provided at driver's side.
17. Oil was changed in transmission parts.
18. Coupling for shunting was introduced.
19. Battery heating was installed and the battery box was insulated.
20. New door steps were installed.

21. The fuel tank was insulated and provided with heating device (loops).
22. Two "Wabasto 2020" heaters were installed.
23. Air pipes were head insulated and provided with heating device.
24. Air dryer was installed.
25. Air distributor was encased.
26. Return valve and air filter (brakes) were encased and heat-insulated.
27. Return valve and regulator were provided with heating device.
28. Automatic draining of air filter was replaced by manually operated draining device.
29. Speeder box was provided with lubrication.
30. Stopping device was replaced.
31. Oil sump of the diesel engine was provided with heating arrangement and thermostat was installed.
32. The gear box was arranged with measuring point for temperature measurements.
33. Warning lamps for high temperature in the gear box were installed in driver's cabs.
34. Oil pipes of the gear box were heat insulated.

35. The load valve was encased and prepared for winter conditions.
36. The brake cylinders were prepared for winter conditions.
37. Electrical heating conductors were installed on the fuel pipe from the tank
38. The fuel tank was head insulated.
39. New generators were installed (increased from 60A to 110A).
40. The diesel engine etc. was encased.
41. Protection of electric cables was introduced.
42. The railbus was lifted 20mm by secondary spring suspension.
43. Shortening of the air hoses to the brake cylinders.
44. Parallel rod was replaced.
45. Electrical insulation of the spring suspension in the A-end of the railbus was provided.
46. Additional electric wiring and equipment was introduced.
47. Snow ploughs were installed.

Modifications made in Canada

1. Two sealed beam headlights No. 200 PAR were installed at each end of the vehicle with a dimming resistance.
2. A single marker light was installed high on each corner of the vehicle. Rotating colored lenses give a choice of red, green or white.
3. A standard flag holder was installed on each corner of the car.
4. A rear illuminated Train Number Board was installed in each top corner of the vehicle with the train no. BREL 75.
5. A standard bronze bell with air ringer was installed under the car between the axles.
6. A standard three tone locomotive air horn was mounted at each end above the driver's cab.
7. A standard CNR locomotive radio base was modified for 30 volt operation and mounted on the luggage rack at the B-end. A standard control head was installed in each control cab.
8. A sill step with grab iron was installed in each of the two corners with no entry step.
9. One powder type fire extinguisher was installed at each end of the car body.
10. A stretcher and first aid kit was installed.

11. An emergency tool kit was installed in a box with a glass panelled door.
12. An uncoupling lever was applied to each coupler.
13. Four push-out emergency windows were added in April to comply with safety practices.

Shore Power Supply

To ensure that the vehicle heating and battery charging systems could function overnight during cold weather with the engine stopped, the vehicle was fitted with a shore power connection intended for a 240 V 50 Hz power supply. When necessary this power was provided by a portable 220 V. 50 Hz diesel generator. During the Jonquiere area operation, the unit was kept overnight in the heated railway shops, with the exception of the shore power test (see p. 19).

TEST PROGRAM

Schedule

- 13 February: Porte 7
Wheel Unloading Tests.
- 19 February: Ville St. Pierre
Yard Tests.
- Checks of bell, horns, safety equipment, headlights.
- Classification and market lights and train number boards.
- Coupling test to LRC locomotive, towbar check.
- Emergency handbrake check.
- 32.2 km (20 miles) per hour brake application.
- 16 degree curve negotiation.
- Torpedo operation check.
- 27 February: Trip to Jonquière
- 28 February: Jonquière
Road Tests.
- Instrumentation of vehicle and track.
- 01 March: Jonquière
Road Tests.
- Calibration of instrumentation.
- Trial runs.

02 March: Jonquière
Road Tests.
- Curving tests.
- Ride quality and stability tests - loaded condition.
- Braking and acceleration tests - loaded condition.

03 March: Jonquière
Road Tests.
- Ride quality and stability tests - unloaded.
- Temperature, noise and vibration surveys.
- Braking and acceleration tests - unloaded.

07 March: Jonquière
Winter Running.
- Trip to St. Félicien encountering deep snow and high winds.

08 March: Return to Montreal

14 March: St. Hyacinthe sub-division
Road Tests.

17 March: Alexandria sub-division
Signal Tests.
- DC track circuit tests (storage and primary batteries).

18 March: Alexandria sub-division
Signal Tests.
- DC coded track circuit tests.

19 March: Alexandria sub-division
Signal Tests.
- AFO track circuit tests.
- DC track circuit crpsomg sogma; tests.
- Hot-box detector model 7707 tests.

21 March: Rouses Point sub-division
Signal Tests.
- Motion detection crossing signal tests.
- Hot-box detector model B909 test.

17 April: Unit shipped to Thompson, Manitoba.

5-9 May: Test run of unit - Thompson, Pikwitonei,
Thicket Portage.

01 July: Regular scheduled non-revenue passenger service
commences three days per week, Thompson, Pikwitonei,
Thicket Portage.

23 August: Scheduled demonstration test runs finished.

September: 141 received in Montreal. Final inspection of
equipment. Testing phase is finished.

DESCRIPTION OF TESTS: FEBRUARY - APRIL

The wheel unloading and road tests were instrumented and supervised by the NRC team. Most tests were made in the Lac St. Jean region on CN track and one stability test was run after the return to Montreal since the desired speed had not been attained. The wheel unloading test was made in the shop at Porte 7 Inc.

The National Research Council Report* (Reference 3) provides the basic data gathered for wheel lift, vibration, curving, acceleration, braking, interior lighting, temperature distribution and noise tests.

Further comments on these tests are:

Wheel Unloading

Individual wheel loads were measured with the vehicle standing with each wheel just clear of the track. One wheel was then jacked to a height of 8.89 cm (3 1/2 in.) above the track (more than 2.54 cm (1 in.) per 3.05 m (10 ft) of wheelbase), and the changes in wheel load noted. Results are tabulated on page 7 of the NRC report. The greatest unloading was 594.2 kg (1310 lbs.) or about 9% of the static load which indicates that some of the twist was absorbed by the chassis flexing.

VIA, Amtrak and CN specifications normally require less than 10% wheel unloading for 2.54 cm (1 in.) wheel lift. Since the LRDC has a wheelbase of nearly 9.14 m (30 ft) as compared with approximately 3.05 m (10 ft) for a normal truck wheelbase it was decided to lift the wheel 8.89 cm (3 1/2 in.) rather than 2.54 cm (1 in.).

*Engineering Tests on BRE-Leyland Rail Bus

Vibration

The vibration analysis is broken down into Ride Quality and Tangent Track Stability analyses.

From the ride quality diagrams (pp. 9-25, Reference 3), it can be seen that at 74 km/h (46 mph) in the empty condition the ISO comfort reduced boundary is 4 hours over the B-end axle, 1 hour over the A-end axle and 8 hours in the car center.

At 80.5 km/h (50 mph) in the loaded condition the figures are 4 hours at the B-end, 2.5 hours at the A-end and 8 hours in the car center.

The lower comfort over the A-end axle may be due to the fact that the B-end axle carries the drive shaft while the A-end axle is undriven.

At 96.6 km/h (60 mph) on CWS track measurements at the A-end only gave 4 hours. The plots of axle accelerations (pp. 19-27, Annex 2) show no instability (hunting) at speeds up to 96.6 km/h (60 mph). The analysis concludes that the performance in this respect meets established VIA criteria.*

Curving

The curving tests were conducted on a curve with a superelevation, as specified by CN's records, of 67.5 mm, giving a balance speed of 48 km/h. It was intended to run through this curve in both directions at 32 km/h, 48 km/h, and 64 km/h, giving superelevation deficiencies of -36 mm, 0 mm, and +50 mm respectively. It was only possible to achieve these speeds in one direction. In the reverse direction, because of the uphill grade, it was not possible to exceed 51 km/h.

*Annex 2, Sect. 2.2 "Review of NRC Report "Engineering Tests on the BRE-Leyland Rail Bus".

After the tests, it was discovered that the actual superelevation was 102 mm, and that the actual superelevation deficiencies were -74 mm, -38 mm, and +12 mm at the three targeted test speeds. Five of the six test runs were below the balance speed for the curve, and the sixth was only marginally above the balance speed.

For this reason, the results of the curving tests are not considered to be useful. However, no erratic behavior was noted during the tests.

Acceleration

The vehicle took 98.2 seconds to reach 72.4 km/h (45 mph) in a distance of 1306 m (4286 ft) in the empty condition, whereas it took 128.6 seconds to reach this speed in a distance of 1705 m (5594 ft) in the loaded condition. These figures indicate a definite lack of power in the vehicle.

Similar tests made in Sweden produced times of 123 seconds in a distance of 1432.6 m (4700 ft) on a section of track with 1% up grades for about 25% of the total distance and 96 seconds in a distance of 1138.4 m (3735 ft) on a section with slight downhill grades. The acceleration is considered low (Reference 1). However the lack of information on the combination of grades and the load carried by the vehicle make these results difficult to judge.

Braking

Stopping distances from various speeds are tabulated (Sect. 3.5, Annex 2) and are further analysed (see Annex 4, "Evaluation of Braking Performance of LRDC Demonstration"). Measured performance is very similar to conventional RDC and locomotive-hauled equipment (Reference 3, "Engineering Tests on Bre-Leyland Rail Bus). Similar tests made on the same car in Sweden gave shorter stopping distances (Ref. 1).

Interior Lighting

Interior light intensities between 11 and 19.1 foot candles were measured at lap height in the passenger seating area. In the aisle intensities were 78 foot candles at eye level and 7 foot candles at floor level. Full results of this test are given in Section 3.4 of Reference 3.

VIA Spec. LRC-3-82 requires an intensity of 25 foot candles at 83.8 cm (33 in.) above the floor, rather higher than lap height.

Interior Temperature Distribution

The temperature distribution was surveyed on a sunny day with the exterior temperature varying from -6 to -8 degrees C and temperature distribution inside the car was greatly affected by the sun. On the shady side, temperatures in the passenger compartments varied from 22 to 28 degrees C. at speeds of 48.3 and 80.5 km/h (30 and 50 mph) while, on the sunny side, temperatures varied from 29 to 37 degrees C at 48.3 km/h (30 mph) in the direct sun and from 26 to 36 degrees C at 80.5 km/h (50 mph). Lower down in the shade on the sunny side temperatures were about 24 degrees C for both runs.

VIA Spec. LRC-3-82 requires that the heating system shall maintain an inside temperature of 24 degrees C with an ambient temperature down to -40 degrees C.

Full results of this test are given in Appendix 11 of Reference 3.

Noise

Sound intensities were measured at 8 selected positions in the car at speeds of between 59.5 and 75.6 km/h (37 and 47 mph). Noise levels were in the range of 64 to 66 dBA with an increase of about 5 dBA near the side doors and with a large increase of about 10 dBA in the passenger area when the auxiliary heater fans were on. The full results are given in Appendix 1 of Reference 3.

VIA Test Plan V-104 for LRC coaches requires that noise levels in the passenger area not exceed 70 dBA at 128.7 km/h (80 mph) on class 6 jointed track or 62 dBA when stationary.

AUTOMATIC SIGNAL TESTING

After returning from Jonquière the vehicle underwent a series of signal operation tests specified and conducted by the Signals and Communications division of CN. During a period of four nights, tests were carried out on D.C. Track Circuit signals using both primary batteries and storage batteries, D.C. Coded Track Circuit signals, AFO Track Circuit signals, a D.C. Track Circuit signal and a Motion Detection crossing signal. Tests were made on two types of Hot Box Detector.

All signals encountered were successfully activated. A full report is made in Annex 3.

In addition to these controlled tests, the LRDC operated all signals on its various road trips to and from test sites.

OTHER TESTS

Overnight Shore Power Test

The vehicle was parked outside overnight the shed with the auxiliary power generator connected with the heaters on.

The ambient temperature was between -12 degrees C and -10 degrees C with violent and gusty winds.

Temperatures inside the bus stayed steady at 22 to 23 degrees C at the car A-end and center while the B-end temperature varied from 26 to 27 degrees C. The only cold area was the toilet. The car was inspected every hour through the night and the heaters all functioned normally.

In the morning the engine was warm and started easily.

Wheel Wear

Dimensions of tread thickness, flange height and thickness and brake block thickness were taken using an AAR wheel gauge at the start of the program and after returning from Jonquière after a total of about 1600 km. Flange height difference was not measurable ($1/64$), indicating negligible tread wear. The flange wear average varied between $1/32$ and $3/32$. Brake block wear was $1/16$ on all blocks measured.

Note: 1600 km is not sufficient to draw any conclusion concerning life or wear patterns.

Fuel Consumption

Careful records of mileage run and fuel added were kept for all movements of the LRDC. Between leaving Porte 7 and returning to Montreal a distance of 1831 km (1138 miles) was covered and an estimated 935 L of fuel added. This gives a mean consumption of 51.1 L/100 km or 5.53 mpg while the two trips between Montreal and Jonquière gave consumptions of 41.6 L/100 km or 6.9 mpg. These consumption figures are significantly higher than those of the Thompson demonstration (see p. 25). This heavier demand derived from considerably extended idling times during the winter test and from fuel used in the unit's heaters.

Reference (1) gives a consumption for the whole test program in Sweden of 60 to 63 L/100 km (7.4 -8.3 mpg).

Snow Ploughing

On March 7 between Chambord and Hébertville the vehicle drove through 30.5 to 50.8 cm (12 to 20 in.) of snow with drifts estimated at 76.2 cm (30 in.) with no problem. The car was stopped and restarted in deep snow. The only problem was freezing on of the brake blocks.

Reliability

The only component failure was one of the alternators which cut out in Jonquière. Inspection showed that the ground leads on both alternators were loose, causing arcing which had destroyed one control circuit board. While waiting for a new circuit board from England, the vehicle continued to run for several days, including the return trip to Montreal on one alternator only.

Technical Tests: Principal Observations

During the tests the vehicle operated satisfactorily under all conditions, although no extreme cold was experienced. (An account of operation in more severe cold is found in Reference 1.) No dangerous dynamic behaviour was found and all types of automatic signals tested were operated without exception.

Systems and components all proved reliable. Malfunction of one of the alternators and subsequent damage was traced to faulty installation causing arcing at the ground terminal.

The LRDC proved suitable for remote service although short of power which limited acceleration, hill climbing and top speed.

Reactions of personnel involved in the program were positive. Most team members were impressed by the ease of operation, maintenance, ride quality and interior finish. Seating comfort was considered adequate although more leg room is desirable. Weatherproofing around the doors is inadequate and the access steps are inconvenient to use.

SCHEDULED OPERATIONS TESTING: MANITOBA

Following the extensive technical tests, as described in the previous section, the BREL 141 was transported to Thompson, Manitoba. This occurred in late April. The purpose was to provide a period of regular passenger service runs between Thompson and the rail-dependent villages of Pikwitonei and Thicket Portage for round-trip distances of 142 and 150 km respectively. This area had since the early 1980s a lively interest in improving its rail transportation in order that such could meet more directly local social needs. The current VIA services of three long-distance Winnipeg-Churchill trains and one local train per week do not permit commuting for these communities at convenient times to Thompson.

Therefore the light rail vehicle or railbus has been conjectured as an economical and reliable means for meeting local needs. With this perspective the second phase therefore became both a socially and technically oriented exercise.

In technical terms, the results sought included:

- an understanding of the vehicle's maintenance requirements as mileage increased;
- an improved understanding of its fuel economy;
- detection of any operational deficiencies in the drive train and other mechanical and electrical systems;
- detection of operational problems from the crewing perspective. The social perspective was to detect problems relevant to public use of the equipment;

- a general understanding of the effectiveness of this equipment in meeting community needs.

Technical Results

The unit, following several non-revenue, non-passenger "dry runs", went into service July 01, on the basis of three operating days per week, with the last run on August 23. The schedule consisted of two round trips Tuesday and Wednesday to Thicket Portage and Pikwitonei, respectively. On Saturday, two full round trips were made embracing both communities. Because of legal and contracting complexities which would have severely delayed the introduction of service, the option of non-revenue service was employed, whereby the passengers were issued free tickets that carried an operator's liability waiver statement.

The BREL LRDC operated Tuesday, Thursday and Saturday of each week, accumulating a total of 7563.7 km (4700 miles). Of the trips made Tuesday to Thicket Portage and returning to Thompson, the unit carried an estimated 724 passengers. The Thursday service to Pikwitonei and back carried an approximately 604 passengers. The Saturday service to both Thicket Portage and Pikwitonei carried 850 passengers for a full total of 2178 passengers.

During those 47 scheduled runs* the crew twice encountered problems with the vehicle. Neither time did it affect the schedule performance.

*The total should have been 48, but one run was aborted through failure of an operating crew member to appear.

The distances and schedules for the runs were as follows:

Thompson-Thicket Portage: 150 km (93 miles) round trip
Thompson-Pikwitonei: 142 km (88 miles) round trip
Thompson-Pikwitonei-
Thicket Portage-Thompson: 193 km (120 miles) round trip.

Operating Schedule BREL 141 LRDC
Thompson-Pikwitonei-Thicket Portage

<u>TUESDAY</u>	<u>THURSDAY</u>	<u>SATURDAY</u>
(THOMPSON-THICKET PORTAGE)	(THOMPSON- PIKWITONEI)	(THOMPSON-THICKET PORTAGE-PIKWITONEI)
DT 0800	DT 0800	DT 0800
ATP 0935	AP 0945	ATP 0935
DTP 0950	DP 1000	DTP 0950
AT 1125	AT 1145	AP 1100
		DP 1115
		AT 1300
6 hours layover	6 hours layover	6 hours layover
DT 1730	DT 1800	DT 1900
ATP 1905	AP 1945	ATP 2035
DTP 1920	DP 2000	DTP 2050
AT 2055	AT 2145	AP 2200
		DP 2215
		AT 2359

SYMBOLS: D - Departure
A - Arrival

T - Thompson
TP - Thicket Portage

P - Pikwitonei

Throughout the test period, in maintenance terms, the maintenance requirements were minimal. Originally a shed was to be provided for storage of the LRDC. This did not occur. Therefore, the unit throughout the test period remained exposed to the elements, with all servicing done outside, without the advantage of pit and other amenities of an inside shop. Fueling was contracted from a local supplier.

The major problem encountered was access to a set of batteries which was blocked by the temporary steps. To check water levels in the batteries, the steps had to be removed. Otherwise the general processes of lubricating and checking the unit were easily and efficiently performed with no special requirements for an access pit or jacks.

During the eight weeks of operation, the engine required only one litre of oil, while the requirements of the fluid coupling, the gear box, the final drive, the splitter box, and the hydraulic system were nil. The only systems requiring further attention were the coolant system and the batteries. The batteries required normal refilling. The coolant system had a small, difficult to locate leak under the body of the unit, which was difficult to rectify. It has been ascertained that coolant leaks are a frequent problem with this type of equipment and should be corrected by changes in hose and clamp specifications.

Fuel economy is always exceptionally difficult to measure against standards for any motive power. Factors such as gauge inaccuracies, idling versus operating time, varying loads and gradients, variations in "topping up" fuel tanks, ancillary power demands upon the drive train permit only a generalized averaging of fuel usage. The Manitoba operation was on generally undemanding terrain, and the fuel average usage was estimated at 26 L/100 km to 28 L/100 km (11-12 miles per gallon).

The unit operated reliably. On two occasions a temporary speed-shift problem arose. On one sustained slow-order section, the unit had problems in the first and second notch ranges, leading to power surges and a sudden and protective shut-down of the engine. Secondly, on another occasion, a problem arose with the shift during operations, but this cleared itself again during the journey. Apart from these incidents, which will be alluded to in the conclusions, the unit was easy to operate and quickly understood by new operating crews. All operational equipment, as applied for North America, functioned well, although occasional minor failures, such as a loosened airline to a horn, occurred.

Because of the modifications to make the unit acceptable for very cold weather operation, several problems arose when the weather became unexpectedly warm.

The original British unit had opening windows as is the custom in British Rail operations. To provide maximum heat and protection, auxiliary heaters and double-glazed sealed clear windows had been installed. The test unit had no air-conditioning, and no direct shut-off control for the auxiliary heaters. As a result, on clear sun lit days, when the temperature turned moderate, the passenger compartment overheated. Several field actions were undertaken to counter this.

1. The air circulation fans were left constantly on.
2. A stop valve was installed on the coolant lines.
3. The four hinged emergency windows were secured at a marginally open position.

These three actions reduced the interior heating problem, but did not eliminate it.

A minor related defect appeared, as a result of the modifications. The emergency windows, which had been installed in Montreal, developed leaks around their perimeter seals. This localized, installation-derived problem, did not adversely affect the summer operation period of the test.

Another design aspect also raised considerable public comment. The unit is configured for British high-level platform access. The rise from the track-level to coach floor is 1280 mm (50.4 in.). In all Canadian locales, except for the Quebec City station and Montreal Central station, high level platforms are nonexistent. The BREL high level access is an unacceptable arrangement for permanent service deployment, but for the purpose of the Thompson test the main concern was to assure safe entry and egress for passengers through crew assistance. This objective was achieved. In order to assist, one community undertook its own action to solve the problem through construction of a temporary high level access.

Operations

The territory of operations consisted of low train movements over jointed rail on roadbed that was subject to undulations caused by frost heaves and thawing. The operations were subject to slow-orders that could restrict train-speed to less than 20 km/h. The area was "dark territory", meaning that there was no railway automatic or inter-linked signalling system. Train movements were performed under a system of train orders and radio-communications.

The LRDC with the exception of temporary speed-range problems operated safely, was stable and did not derail. The crews adapted quickly to the unit, learning the controls and necessary systems often in a matter of minutes. However, it is clear that experience increased the crews' ability to extract the best performance. The major crewing problem was associated with the operating context, rather than the unit itself.

Because of the remoteness of Thompson from other crewing bases at Gillam and The Pas, and the nature of the scheduled service demands, the service was vulnerable if a crew-member "booked off" or failed to appear. This happened on two occasions, one of which caused exceeding inconvenience to the dependent public through cancellation of one round trip .

The scheduled runs were twice affected by temporary failures in the radio communications system, but these were quickly rectified. At no time was the safety of operation or the general efficacy of the service affected by train-control questions. Regional headquarters in Winnipeg responded to the temporary operations problems with alacrity. Delays were occasioned by the considerable isolation of the site. The attitude of CN was constructive and helpful.

Public Response

Apart from the continuing investigation of the operational and mechanical abilities of the LRDC, the Manitoba portion of the service was designed in its scheduling for local public utility, and to gain a public response to the LRDC concept. The communities are looking for better access, a local rail service in order that they may access Thompson for an adequate period during business hours.

Several unique features defined the public attitude to the test service. The communities of Pikwitonei and Thicket Portage are rail-dependent, with no roads; therefore the test passengers could be described as captive clientèle. Secondly, the test service was free, with tickets issued on a first-come basis.

The VIA field officer conducted random verbal surveys with three basic objectives: (1) to ascertain the reason for the individual's trip; (2) to ascertain the individual's reaction to the LRDC; (3) to note suggestions for service and vehicle improvements. As well, local community and regional representatives were queried as to their opinions.

Unfortunately the results in terms of reasons for travel were skewed by the issuance of the free tickets, the school holidays, and the number of children travelling for the pleasure of the journey. However, the service was used for a diversity of necessary ends, including medical appointments, employment access, access to banking facilities, shopping, (including acquisition of spare parts for vehicles), visiting family and friends, and social and recreational outings. Several ad hoc examples also indicate the utility, or potential, of this type of service: the unit carried passengers going to a wedding, sport instructors, education staff and local community and political representatives on their visits. Fishermen, construction workers and tourists were also carried. The sample results were disproportionally weighted towards children travelling, which would not be the case were a fare-paying requirement introduced.

Sufficient information was deduced to indicate that the service would be useful for business, medical, shopping, educational, social and recreational reasons, and would considerably enhance the mobility of the residents of these communities. The unit was also seen as a potential means of commuting for inter-community sports and social events, and as a possible charter-vehicle for fishermen, construction workers proceeding to sites along the line, and as a means of access to other communities along the mainline.

The fear was expressed that ultimately a decision may be required for the introduction of a local LRDC service with a consequent elimination or reduction of the existing long-distance trains.

The reaction to the BREL unit was generally positive, although criticism came, as expected, of the high-level platform access requirement. The temporary steps were a challenge, and would not be acceptable on a permanent service.

As well, for a permanent service, more baggage space was considered to be desirable.

The major problem in terms of attitudes to the service itself arose with the "first-come-first-serve" ticketing, often monopolized by children, when the excluded adults had greater reason for travel. VIA was asked if it could exercise control over who received tickets, in favour of adults. The test operator responded that it could not police in this manner, and that the problem would need to be solved by the communities. It is doubtful, if ever a permanent service is established, that the problem would be of this magnitude, as the imposition of fares would be an effective control. The unfortunate result of the crowding was that on occasion people were turned away who then considered that they had had unfair treatment.

The timing of the service attempted to meet the communities' desire for a significant lay-over period in Thompson. However, a problem lay in the early closing of the Thompson VIA station, after the regular long-distance passenger train had left. For the evening departures, passengers would arrive and would be unable to access the structure, which is in a fairly isolated locale. This problem was resolved with the VIA field supervisor acquiring a key and allowing passengers into the building prior to train time.

The attitude of the users was helpful and the equipment was very well treated by the passengers. Considerable effort was made to keep the unit clean inside and outside with locals employed for this purpose along with the efforts of the BREL and VIA employees.

TECHNICAL OBSERVATIONS: TOTAL TESTING PHASE - FEBRUARY/AUGUST 1986

Throughout the operation of the LRDC, a series of working evaluations and observations were carried out. These were related to unit and power train design, materials, and performance of the LRDC under Canadian conditions.

Frame and Underbody

1. The present snow plough-coupler combination must be modified to give full coupling ability at both ends. Coupler height must be raised to within acceptable AAR tolerances.
2. The present location of the battery boxes prevent coupling at the A-end and, additionally, one battery cannot be serviced without removing the access steps.
3. The snow plough functioned well, but only under very limited snow drift duration. Its adequacy requires further testing.
4. The main air reservoir and air piping should be modified to avoid danger of damage by ice or packed snow.
5. The protective shroud under the car should either be removable or have hinged access panels for servicing under-car equipment.
6. Engine power is barely adequate.
7. The transmission shifts very slowly causing serious loss of speed on upgrades.

8. Battery boxes will require better accessibility for water addition and specific gravity checks.
9. Vent should be added to diesel fuel tanks.
10. Better quality fuel gauges should be applied which can be read at the standing position.
11. A gauge for coolant should be added, which can be read at a standing position.
12. Battery isolation switches, both start and auxiliary, should be moved inside the cab.
13. Throttle speeds should be adjusted in order to permit finer speed gradations in lower ranges.
14. To function and service efficiently in absence of pit access, a means of ascertaining oil levels in the fluid coupling, gearbox, the final drive, the splitter box and hydraulic system is needed. Currently such inspection must be performed completely under the unit.
15. A flexible rubber hose with ordinary squeeze type clamps should be considered for employment within the coolant system.
16. Stop valves should be employed in the coolant system feeding the auxiliary heaters in the body of the cab in order that flow can be stopped when required.

Passenger Amenities

17. The access steps are inconvenient for track-level loading. Folding or permanent steps should be applied to permit easy passenger access at low-level platform and unimproved sites.
18. The door seal is inadequate although the door operating mechanism works well. Perhaps the accordion style door is not suitable.
19. Heating distribution should be improved. Warm air ducts at the base of the side walls may be needed. The toilet, in particular, needs improvements to heating and ventilation.
20. A wider body could give great returns in terms of passenger comfort and convenience.
21. The air circulatory fans are too noisy.
22. In warm weather the 141 became very hot in the body compartment. As an interim measure simple opening windows could be considered. However, requirements for double-glazing and tight seals, and for protection against insects indicate a longer term requirement for tinted glass or shields from direct sunlight, and for air-conditioning.

Areas of Investigation

1. Are the 110 Amp. alternators adequate in winter?
2. Is the compressor adequate for the extra demands of Canadian service?
3. Are cable operated brakes reliable?
4. Will the protective shrouds cause engine over-heating in hot weather?
5. Is 220 V.60Hz. shore power suitable to the vehicle? If not, can the vehicle be adapted to this?
6. Can the axle alignment be accurately checked in workshop conditions?

CONCLUSIONS AND RECOMMENDATIONS

The BREL 141 operated efficiently during its test period. Within the parameters of the program, the unit was demonstrated to be safe, reliable, economic, with a distinct potential for passenger service application in Canada.

All necessary equipment for safe operation, such as external lighting, radio, number boards, flags, etc. was installed and operated reliably. The operating crews generally found the layout and operating methods acceptable. Train operations were efficiently and safely performed.

The unit's performance in the stability tests was found to be safe. Prior to this, no certain projection could be made as to stability, ride quality and braking under varying Canadian track and road bed conditions.

The signalling performance, expertly monitored by CN, was of major interest. The complete activation of all signals under the tests, and in vehicle movement throughout the railway system indicates that the unit can be operated safely through most types of signalled territory. In terms of traffic control, dispatchers were able to track the unit at all times.

Because the unit arrived late in Canada, winter operations were limited to a short duration run from Montreal to Jonquière, and certain test runs in the area, with the minimum temperature being -21 C. During this period, snow and drifting conditions were encountered, accompanied by occasional strong winds. Through this the LRDC performed reliably. These tests were not affected by a localized failure in one of the alternators; the unit continued to carry out all necessary functions, including the extended return run to Montreal on the single remaining alternator.

Longer-term maintenance requirements can still be only generally extrapolated, in large part because of the very light maintenance demands of the unit throughout the period. The empirical results are very encouraging; for example, through the Thompson test period the unit required one litre of oil. The number of service kilometers totalled less than 7564 (4700 miles), with much of this through temperate conditions. To truly ascertain the LRDCs reliability and maintenance requirements, more operation in varying conditions will be necessary.

The ease of maintaining the unit, including access to essential systems in unimproved locales without a pit, exists for a number of functions. The empirical and normal service evidence implies that components and systems are accessible, or can be made accessible to a large degree. Drawbacks resulted from the effects of modifying the unit for one purpose, e.g. application of the low-level steps for Canada, which blocked out another purpose: access for servicing a battery set. However, caution is required before a firm extrapolation can be made in regard to ease-of-access and maintainability. The 141, although specifically modified for Canadian conditions, is less developed in this regard than its successor, the BREL 142 series. The general conclusion is that the maintenance requirements and efficiency potentials require further study.

The degree to which maintenance procedures can be simplified and reduced for any railway unit should not be exaggerated. The "railbus" concept ideally implies a self-propelled passenger unit that can be operated with minimum servicing in remote rudimentary settings. This may be achievable, but the regulated requirements for safe and reliable operations under traffic control even on the lightest density routes, signalled or unsignalled, through extremes of climate in often very isolated regions, implies a continuing comprehensive quality maintenance procedure. Several technical trades are necessary to this end.

The test cycle process made considerable demands upon planning, costing, contracting, legal, maintenance, engineering, and transportation operations disciplines. The contracting process required careful attention, particularly in the beginning, where the newness of the equipment posed many questions from essential safety through to operability under varying conditions. Ultimately the cooperation in clearing the hurdles worked well and credit is due to the operating railway, the subcontracted shops and consultants, and the CTC for the effectiveness of their assistance, once the nature and abilities of the LRDC were understood.

VIA, the Canadian Transport Commission, and CN were required to analyze and set conditions for each stage of the unit testing, from its first movement into the yards, through the technical evaluations, winter operations, and non-revenue passenger scheduled service in Thompson. At each stage vigorous efforts were required to define the safe and reliable way of permitting this new technology to operate. While considerable knowledge of its abilities has been acquired, this inter-agency participation is implicit in the continuing analysis of safety and operating procedures.

A second stage test program is recommended. It should have the following objectives:

- The unit should operate through extended canadian winter conditions in order to more fully determine its operability in extreme cold, and ice and snow. The effects on drive train, air systems, electrical functions, brakes, and other principle components should be closely monitored.

- Sufficient mileage and operating hours should be accumulated to permit evaluation of the reliability of the unit. Equipment deterioration or failure should be closely monitored; maintenance procedures and temporary repairs should be detailed, with suggested design changes noted.
- The viability and durability of the drive train, vehicle systems, and all mechanical aspects should be assessed in terms of simplicity of procedure, serviceability parts availability, and the maintenance infrastructure required to complete these tasks. The potential for basing an LRDC-type in secondary locals, away from main railway shops, should be assessed.
- The appropriateness of drive train and related systems' power delivery should be rated against power demands on a modified "Canadian" LRDC. Such increased demands could include operation of the unit through varying load, climate, track, and grade conditions and would also include increased electrical power requirements.
- If possible, the more advanced, paired unit LRDC, the BREL 142, should be tested for certain essential functions. These should include: activation of signals, operation by Canadian crews, stability, ride quality, acceleration, and braking performance at speeds up to the 142's maximum.
- The structure and operational equipment should be assessed against operational safety criteria. The variance between Canadian and European approaches to safety should be assessed, and remedial steps recommended if necessary, either through design changes or altered operational conditions. In accord with this, the degree to which the BREL LRDC meets North American governmental regulations and railway rules should be ascertained.

- The characteristics of a potential "Canadian" LRDC should be matched to the types of remote/regional and other service mandates it could perform. Equipment standards should be defined in terms of such items as low-level platform access, ride quality, on-board comfort and amenities, and comparability with existing service quality.
- A performance specification should be formulated which would permit a manufacturer to design an LRDC that could be easily maintained, and economically and effectively operated in specified Canadian conditions.
- The general economies of employing LRDCs should be defined. The analysis should include the impacts of capital costs, operating costs, and the potential for cost reductions on specified services.

